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Safety

SPACE SAFETY AND MISHAP PREVENTION PROGRAM

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This Air Force Instruction (AFI) implements Air Force Policy Directive (AFPD) 13-6, *Space Policy*, AFPD 91-2, *Safety Programs*, and the relevant safety portions of Department of Defense Directive (DoDD) 3100.10, *Space Policy*, DoD Instruction (DoDI) 3100.12, *Space Support*, DoDI 3200.18, *Management and Operation of the Major Range and Test Facility Base*, *Memorandum of Agreement between the Department of the Air Force and the Federal Aviation Administration on Safety for Space Transportation and Range Activities;* and in conjunction with AFI 91-202, *The US Air Force Mishap Prevention Program*, provides guidance for implementing a Space Safety and Mishap Prevention Program. It provides guidance to develop comprehensive Space Safety and Mishap Prevention Programs for existing and future space systems. This instruction also contains the minimum acceptable risk criteria required for safe space operations and testing. It applies to all active duty Air Force (AF), Air Force Reserve, and Air National Guard units that design, develop, modify, evaluate, test and/or operate existing and future Air Force space systems (operational, test, and experimental), Air Force space support systems, or use or operate Air Force launch facilities or ranges. The authorities to waive wing/unit level requirements in this publication are identified with a Tier ("T-0, T-1, T-2, T-3") number following the compliance statement. See AFI 33-360, *Publications and Forms Management*, Table 1.1 for a description of the authorities associated with the Tier numbers. Submit requests for waivers through the chain of command to the appropriate Tier waiver approval authority, or alternately, to the Publication Office of Primary Responsibility (OPR) for non-tiered compliance items. Ensure that all records created as a result of processes prescribed in this publication are maintained IAW Air Force Manual (AFMAN) 33-363, *Management of Records*, and disposed of IAW Air Force Records Information Management System (AFRIMS) Records Disposition Schedule (RDS). The use of the name or mark of any specific manufacturer,

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SUMMARY OF CHANGES

This document has been substantially revised and must be completely reviewed. Major changes primarily involve the removal of large amounts of purely descriptive non-directive material deemed non-essential for the purposes of an Air Force Instruction. For simplicity, this revision combines Chapter 3 and Chapter 2 of the previous revision, and incorporates the relevant portions of Chapter 8 into Chapter 6. This revision also deletes Chapters 7 and 9 of the previous version.

This revision combines the Spacecraft Space Debris Assessment Report (SDAR) and the Spacecraft End-of-Life Plan (EOLP) into a single document whose content and format is described in Attachment 3. The Launch Vehicle Space Debris Assessment Report, described in Attachment 2, is still submitted separately. Publication consistently denotes casualty expectation (E_c).

Chapter 1

SPACE SAFETY PROGRAM

1.1. Scope.

1.1.1. This document implements Space Safety and Space Mishap Prevention guidance for all Air Force space systems throughout all system life cycle phases.

1.1.2. Purpose. The Air Force operates responsibly with due regard for the safety of the general public, Air Force personnel, space support personnel, and public and government resources. This document provides overarching Space Safety and Space Mishap Prevention guidance for acquisition, testing, and life cycle operations of terrestrial, launch, and orbital space systems.

1.1.3. Applicability. This instruction is applicable to all Air Force organizations that develop, test, or operate any space system, or who provide launch/range services for space systems. This includes space systems under development, research and development systems, experimental systems, systems undergoing testing, operational systems, and systems at end-of-life (EOL). This instruction is applicable to the entire mission if the Air Force is the lead launching, manufacturing, or operating agency. For missions where the Air Force is not the lead launching, manufacturing, or operating agency, this instruction is applicable for all segments under Air Force control.

1.1.3.1. Mission Partner Responsibilities. All participating organizations within a mission partnership should establish Memorandums of Agreement (MOAs) or Memorandums of Understanding (MOUs) outlining each organization's responsibilities and requirements with regard to Space Safety and Mishap Prevention.

1.1.3.2. Joint/DoD/Non-DoD Space Safety Guidelines. Organizations operating in a joint environment or with non-DoD agencies should develop MOAs/MOUs that specify the applicable space safety guidelines. It is the participating organizations' responsibilities to determine the lead agency and proper approval authorities. Consult with Numbered Air Force (NAF) and MAJCOM/SE, as appropriate.

1.1.3.3. Existing Systems. This instruction does not require modification of existing space systems and system upgrades that have completed their System Requirements Review prior to Feb 2010, nor does it require demonstration of compliance with requirements in this AFI that did not apply to those systems prior to that time. However, consistent with cost effectiveness and mission requirements, adhere to any aspect of this instruction that can be met without significant analysis or design change. When feasible, apply the updated requirements in this document to any future documentation, design changes, or system modifications required. Qualitative information indicating that existing systems meet the intent of the requirement(s) may be used to demonstrate an equivalent level of safety. Note: compliance with requirements sourced from previously published documents (e.g., orbital debris mitigation requirements in DoDI 3100.12, 14 Sept 2000) is still mandatory

1.1.4. Terminology. This instruction uses the term "appropriate Wing Commander/System Program Office (SPO) Director" throughout. Therefore, MAJCOMs will identify the

appropriate Wing Commander/SPO Director in their supplements to this instruction and will specify when safety responsibility transfers between organizations. The SPO is the office of the Program Manager (PM) and the single point of contact with industry, government agencies, and other activities participating in the system acquisition process.

1.1.5. Waivers. When complying with official policy, guidance and/or procedures designated with a Tier Waiver Authority number, the unit may request a waiver IAW AFI 33-360, *Publications and Forms Management*. Refer to AFI 33-360 Tier Waiver Authority number definitions (i.e., T-0, T-1, T-2 or T-3). In addition to the waiver requirements of AFI 33-360, this instruction includes the following requirements:

1.1.5.1. Reevaluate any risks created by the waiver throughout the waiver period and adjust risk controls as necessary IAW AFI 90-802, *Risk Management* and AFI 91-202, *The US Air Force Mishap Prevention Program*.

1.1.5.2. Each commander/director will keep, at a minimum, the previous commander's/director's waivers on file IAW their file plan. (T-3)

1.1.5.3. Ensure a copy of the approved waiver is sent to the OPR of the affected AFI. (T-3)

1.1.5.4. Each applicable Safety Office shall brief previously approved and active safety waivers to incoming commanders, system program managers, and Chiefs of Safety within 90 days of assignment. (T-3)

1.2. Space Safety.

1.2.1. Space Safety is a dynamic process designed to improve operational effectiveness by managing or preventing close calls (events), reducing mishaps, and supporting mission assurance throughout the life cycle of a space system. It includes launch/range safety, orbital safety, ground-based space safety, system safety, software safety, risk management, and mishap investigation and reporting.

1.2.2. Space Mishap Prevention. Space Mishap Prevention is a continuous process that begins in the early acquisition phases of a Space Safety Program and continues through the system's EOL; it includes reentry, recovery, and disposal activities for applicable systems. Supervisors at all levels shall execute established risk management (RM) practices/procedures throughout all phases of a space system's lifetime. (T-0)

1.2.3. Space Mishap Investigation and Reporting. Supervisors at all levels shall ensure that any space mishap is investigated and reported IAW AFI 91-204, *Safety Investigations and Reports*, and AFMAN 91-222, *Space Safety Investigations and Reports*. Contact MAJCOM/SE and HQ AFSEC/SES for documenting classified space mishaps. (T-3)

1.3. Space Safety Council (SSC).

1.3.1. The SSC shall assist the Air Force Chief of Safety or designated representative in fulfilling oversight responsibilities through effective governance and management. The SSC will: 1) recommend DoD/Federal and Air Force safety policy; 2) prepare and monitor DoD/Federal and Air Force directives and/or instructions concerning Space Safety issues; 3) promote Space Safety initiatives for DoD/Federal space flight using Air Force resources; 4) recommend, prepare, monitor, and promote policies, directives, and/or instructions for commercial Space Safety, especially those associated with Air Force resources; 5) maximize

collaboration with organizational Space Safety Offices; 6) discuss Space System Safety issues; and 7) provide an independent assessment of the overall Space Safety Program. HQ AFSEC/SES chairs the SSC and Air Force Space Command Director of Safety (HQ AFSPC/SE) is vice-chair.

1.4. Space Safety Training.

1.4.1. Assigned Space Safety personnel shall receive training in Space Mishap Prevention, Space Mishap Investigation, and all other aspects of Space Safety appropriate for the duties and missions of their assigned organization. (T-3)

1.4.2. Operational and acquisition space organizations shall provide initial and annual Space Safety training to military and government civilian personnel. Organizations shall create training tailored to the personnel's assigned tasks and positions. (T-3)

1.4.3. Units shall establish risk management-derived procedures to prevent mishaps while training on live operational systems.

1.5. Space Safety Staff.

1.5.1. Organizations acquiring, testing, and/or operating space systems must have the following positions, as applicable: (T-3)

1.5.2. Chief of Safety (CoS). At a minimum, wing-level organizations conducting operational space or space test missions shall have a Chief of Safety. MAJCOM Safety Offices shall determine which additional subordinate wing-level organizations require a CoS.

1.5.3. Space Safety Officer (SSO). Each wing-level space organization shall assign an SSO for each subordinate unit. In addition, each space system program office must have an SSO. System Safety Managers (SSMs), Mission Safety Officers (MSOs), Mission Flight Control Officers (MFCOs), Launch Safety Officers (LSOs), and/or Orbital Safety Officers (OSOs) may fill these positions as applicable to the program's mission.

1.6. Safety Office Responsibilities.

1.6.1. MAJCOM Responsibilities. Each MAJCOM shall develop and administer a Space Safety Program appropriate to that MAJCOM's involvement with space systems. At a minimum, the MAJCOM Safety Office shall:

1.6.1.1. Keep the MAJCOM Commander apprised of Space Safety issues.

1.6.1.2. Implement Space Mishap Prevention policies, standards, and procedures.

1.6.1.3. Establish criteria to measure the success of the Space Mishap Prevention Program.

1.6.1.4. Ensure subordinate units develop Space Safety Programs that comply with formal guidance.

1.6.1.5. Ensure assigned Space Safety personnel and subordinate units comply with Space Safety training requirements.

1.6.1.6. Identify and document individuals who have Safety Investigation Board (SIB) training and are eligible to execute the duties associated with mishap investigations.

1.6.1.7. By 1 October each year provide HQ AFSEC/SES with all MAJCOM Commander approved and active waivers to this publication.

1.6.1.8. Establish MOAs with or on behalf of non-Air Force organizations to ensure understanding and implementation of requirements and policies of affected organizations. MOAs will address which Space Safety policies apply to Air Force personnel assigned to non-Air Force organizations (e.g., National Reconnaissance Office (NRO), Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA)).

1.6.1.9. Establish MOAs with international partners, as appropriate, to address organizational roles and responsibilities in the event of a mishap. This will include, at a minimum, designation of lead or participation in the investigation and assigned roles and responsibilities. The MOA will specify releasable information obtained by the investigation. Follow the procedures of AFI 51-701, *Negotiating, Concluding, Reporting, and Maintaining International Agreements*, when preparing an MOA.

1.6.1.10. Determine which operationally-related safety issues require coordination with Joint Functional Component Command for Space (JFCC Space).

1.6.1.11. Assist the NAF/Center in determining the scope of the duties for NAF/Center assigned SSOs.

1.6.1.12. Establish Interim Safety Board (ISB) requirements.

1.6.2. NAF/Center Responsibilities. Each NAF/Center that develops, tests, and/or operates space systems shall develop and administer local Space Safety guidance appropriate for their organization. At a minimum, the NAF/Center Safety Office shall:

1.6.2.1. Keep the NAF/Center Commander apprised of Space Safety issues.

1.6.2.2. Assist subordinate units in developing Space Safety Programs, Space Safety procedures, and related training applicable to their assigned missions.

1.6.2.3. Ensure assigned personnel comply with Space Safety training requirements.

1.6.2.4. Identify and document individuals who have SIB or Single Investigating Officer (SIO) training and are eligible for mishap investigation duties.

1.6.2.5. Ensure subordinate units employ the appropriate level/authority of risk acceptance for all Space Safety-related risk decisions.

1.6.2.6. Assist subordinate units and program offices in determining the appropriate number, scope of duties, and training for SSOs.

1.6.3. Wing/Directorate-level Organization Responsibilities. Organizations that maintain, upgrade, test, operate, and/or dispose of space systems will coordinate with the NAF/Center Safety Office to implement a Space Safety Program. At a minimum, the Wing/Directorate Safety Office shall: (T-3)

1.6.3.1. Keep the Wing/Directorate Commander apprised of Space Safety issues. (T-3)

1.6.3.2. Ensure subordinate units execute Space Safety Programs, provide oversight to local Space Safety Programs, and train to ensure compliance with formal guidance. (T-3)

1.6.3.3. Ensure each subordinate unit has at least one trained SSO appropriate to their mission. (T-3)

1.6.3.4. Manage, as applicable, the Launch/Range, Orbital, Ground-Based, or System Safety Program for the commander/director. (T-3)

1.6.3.5. Identify and document individuals who have SIB or SIO training and are eligible for Class C or D mishap investigations and Class E High Accident Potential (HAP)/event investigations. (T-3)

1.6.3.6. Ensure all agreements with mission partners have applicable reporting requirements and/or contractual mechanisms. (T-3)

1.6.4. Program Executive Officer (PEO) responsibilities. The PEO shall:

1.6.4.1. Ensure Program Managers (PMs) coordinate with the NAF/Center Safety Office to implement appropriate elements of a Space Safety Program.

1.6.4.2. Ensure PMs execute Space Safety Programs, and provide oversight and training to ensure compliance with formal guidance.

1.6.4.3. Ensure that each program designates at least one trained SSO.

1.6.4.4. Identify and document individuals who have SIB or SIO training and are eligible for Class C or D mishap investigations and Class E HAPs/event investigations.

1.7. Tenant and Geographically Separated Units (GSU).

1.7.1. Tenant units and GSUs shall establish/maintain a Space Safety Program IAW the requirements of their parent organization and this document. Mishap reporting is the responsibility of the owning organization. (T-3)

Chapter 2

SPACE SYSTEM SAFETY, RISK ACCEPTANCE, AND WAIVER AUTHORITY

2.1. System Safety.

2.1.1. System Safety is the application of engineering and management principles, criteria, and techniques throughout all phases of the system life cycle to optimize safety within the constraints of operational effectiveness, mission assurance, time, and cost.

2.1.2. Consistent with National Space Policy, DoDD 3100.10, DoDI 3100.12, and DoDI 5000.02, *Operation of the Defense Acquisition System*, Space Program Managers, Operators, and System Safety Managers shall ensure that Space System Programs:

2.1.2.1. Incorporate System Safety into the design of space systems, subsystems, and components.

2.1.2.2. Incorporate System Safety processes into system engineering efforts at all levels and throughout each and every phase of the space system life cycle.

2.1.2.3. Document System Safety processes and requirements IAW, AFI 63-101/20-101, *Integrated Life-cycle Management*, AFI 91-202, AFI 91-204, and MIL-STD-882, *DoD Standard Practice: System Safety*.

2.1.2.4. Identify hazards and manage mishap risk potential at the appropriate level during each phase of the space system life cycle.

2.1.3. The appropriate Wing Commander/SPO Director or equivalent shall: (T-3)

2.1.3.1. Ensure System Safety practices are included and applied in all product or service contractual arrangements. (T-3)

2.1.3.2. Ensure System Safety practices are integral to the systems engineering process. (T-3)

2.1.3.3. Identify a government-appointed lead System Safety Manager to execute or oversee the System Safety program. (T-3)

2.2. Risk Acceptance and Waiver Approval Authority.

2.2.1. This section contains general or overarching risk acceptance and waiver approval guidance. Refer to subsequent sections for specific risk acceptance and waiver approval authorities. Reference AFI 91-202, AFMAN 63-119, *Certification of System Readiness for Dedicated Operational Test and Evaluation*, Range Commanders Council (RCC) standards, and MAJCOM instructions/manuals for additional guidance on risk criteria. Air Force exception to National Space Policy shall staff through Headquarters Air Force, Space Operations (Air Force/A3S) for Secretary of Defense approval.

2.2.2. The organization’s commander or equivalent is responsible for those risks that are within their authority and capability to mitigate or otherwise control. At all times throughout a space system’s life cycle there shall be a designated risk responsible organization identified in writing.

2.2.3. Air Force space personnel shall not be exposed to hazards that exceed the requirements in AFI 91-203, *Air Force Consolidated Occupational Safety Instruction*.

2.2.4. The Air Force Civil Engineering Center (AFCEC) is the waiver authority for all facility changes that do not meet the minimum requirements of Unified Facilities Criteria (UFC) 1-200-01, *General Building Requirements;* and UFC 3-600-01, *Fire Protection Engineering for Facilities*.

2.2.5. All facilities (including launch pads) that house spacecraft, launch vehicle components, or systems that present an explosive hazard shall be sited and operated IAW Defense Federal Acquisition Regulation Supplement (DFARS) 252.223-7002, *Safety Precautions for Ammunition and Explosives,* DoD 4145.26-M, *DoD Contractor's Safety Manual for Ammunition and Explosives*, DoD 6055.09M, *DoD Ammunition and Explosives Safety Standards*, and AFMAN 91-201, *Explosives Safety Standards*.

Chapter 3

SYSTEM DEVELOPMENT AND PRODUCTION SAFETY

3.1. System Development.

3.1.1. This chapter covers safety responsibilities for space or space-related hardware through key acquisition phases outlined in DoDI 5000.02. An acquisition approach will consider safety throughout design, development, integration and test, and shipment to the launch or operational location.

3.1.2. Design decisions have the potential to impact the operational safety of a system. Therefore, the acquisition organization shall address the impact of design decisions on the launch, on-orbit, reentry, and disposal/EOL requirements in this document during acquisition phases. Acquisition organizations shall comply with all safety standards that address these downstream risks. The acquisition organization is also responsible for all of its follow-on sustainment activities.

3.1.3. Where risk responsibilities overlap organizations, all mission partners shall refer to the MOAs/MOUs described in Section 1 for risk responsibility guidelines.

3.2. General Design Considerations.

3.2.1. Consistent with National Space Policy, the requirements in this document, and considering mission requirements and cost effectiveness, PMs and SSMs shall address the following general design guidance in all appropriate requirements documents: (T-1)

3.2.2. Minimize space system vulnerability to natural and man-made space hazards. (T-1)

3.2.3. Minimize generation of space debris. Refer to subsequent sections for detailed analysis guidelines. (T-1)

3.2.4. Minimize the possibility of catastrophic loss or mission degradation due to collisions with debris. Refer to subsequent sections for detailed analysis guidelines. (T-1)

3.2.5. Minimize functional, electro-magnetic/optical or physical interference with other systems or personnel. (T-1)

3.2.6. Plan for disposal operations (passivation) for launch vehicle components, upper stages, spacecraft, and other payloads at EOL to minimize the impact on future operations. Refer to subsequent sections for further guidance. (T-1)

3.2.7. Establish clear decision authorities for configuration control and management. (T-1)

3.2.8. Minimize human error through the design characteristics IAW DoDI 5000.02 and AFI 63-101/20-101. (T-1)

3.2.9. Conduct tests of hardware in as close to the operational environment as possible IAW AFI 99-103, *Capabilities-Based Test and Evaluation*. (T-1)

3.2.10. Develop, test, and incorporate safety critical software IAW MIL-STD-882 and *Joint Software Systems Safety Engineering Handbook* when planning a software safety program. (T-1)

3.3. Performance Reviews.

3.3.1. Space Safety personnel shall participate in system program performance reviews/assessments during the system development phase. (T-3)

3.3.2. Space Safety Programs shall emphasize test program validation (to include procedures discipline, readiness reviews, and test execution risk management) and configuration control in order to minimize mishaps. (T-3)

3.4. Transportation.

3.4.1. Plan and execute the transportation of high-value and/or hazardous space systems to minimize hazards posed to and by the space system.

3.4.2. The responsible Air Force SPO Director shall develop and approve a transportation plan (or equivalent document) for transportation from the factory to the operational site or range. The receiving Wing Commander/SPO Director, if any, shall coordinate on the plan. (T-3)

3.5. Assembly and Checkout.

3.5.1. Safety responsibility for assembly and checkout is normally the responsibility of the SPO Director or equivalent acquiring the system. If the potential hazards from this sub-phase can extend beyond the boundaries of the involved facility, the installation commander is responsible for the protection of other resources and personnel. After operational capability certification, the operational Wing Commander assumes operational safety responsibility. All mission partners shall refer to the MOAs/MOUs described in Section 1 for risk responsibility guidelines.

3.6. Personnel and Resource Protection.

3.6.1. Consistent with Commercial Space Operations Support Agreements and other local agreements, Space Safety Programs shall incorporate designs to protect Air Force personnel and the general public from accidental death, injury, and/or occupational illness and protect Air Force systems, equipment, material, and facilities in the launch area from damage or delayed operation as a result of space related operations. (T-3)

3.6.2. When the Air Force enters into a contract or written agreement transferring use of a facility to another organization, the responsibility for personnel and resource protection is simultaneously transferred, upon host safety approval.

3.7. Risk Acceptance and Waiver Authority.

3.7.1. All risk acceptance and AFI 33-360 waiver authority in the development phase shall be IAW DoDI 5000.02, AFI 63-101/20-101, and this document.

Chapter 4

LAUNCH & RANGE SAFETY

4.1. Pre-Launch, Launch, and Reentry.

4.1.1. This chapter outlines safety responsibilities and tasks for pre-launch processing at the launch site, launch operations, and the reentry of launch vehicle components or reentry vehicles. It includes safety responsibilities and requirements for launch vehicles/components, reentry vehicles/components, controlled reentry, and reusable launch vehicles/components, including their jettisoned components. For on-orbit disposal safety responsibilities and requirements for spacecraft or launch vehicle components that remain in orbit, see Section 5.

4.1.2. The Space Wing shall ensure each range user complies with all Air Force launch/range safety requirements levied upon them as a condition of Air Force range use. (T-3)

4.1.2.1. FAA-licensed launches from Air Force ranges are also subject to the requirements of other agencies, including FAA/AST (FAA Office of Commercial Space Transportation). Use established agreements for ensuring safety compliance for FAA-licensed launches.

4.1.2.2. In some cases, agreements with local governments or national guidelines may also apply and require range compliance.

4.2. Safety Responsibilities.

4.2.1. Different aspects of launch and range safety may be the responsibility of different authorities. For example, the protection of a system’s equipment from internal hazards may be the responsibility of the SPO Director while the protection of the public from a space program's ground and/or flight hazards may be the primary responsibility of the Space Wing Commander.

4.2.2. The Space Wing Commander is responsible for all flight risk to the general public, launch area personnel, and other mission support personnel. This responsibility for personnel safety extends from liftoff through orbital insertion or from liftoff to impact for suborbital launches. It includes jettisoned launch vehicle components and debris released prior to orbital insertion.

4.2.2.1. Launch range safety personnel shall undergo the appropriate training (as determined by the MAJCOM Safety Office) for their assigned positions. (T-3)

4.2.3. The launch vehicle SPO Director is responsible for risk to the general public from upper stage reentry following orbital insertion. The launch vehicle SPO Director is also responsible for safing disposed upper stages, maximizing compliance with debris mitigation guidance, and recovering identifiable launch vehicle (upper stage) debris that lands in foreign territory and/or the United States.

4.2.4. The spacecraft SPO Director is responsible for development safety, management of system hazards, and protection of the space program’s equipment from internal hazards during the pre-launch phase. The spacecraft SPO Director is responsible for spacecraft Orbital Safety from separation of the last launch vehicle component through early orbit

testing and until the operational organization assumes Satellite Control Authority (SCA). Refer to Section 5 for Orbital Safety guidelines.

4.2.5. Commanders or directors of activities managing Major Range and Test Facility Bases (MRTFBs) are authorized to terminate, prohibit, or suspend immediately any DoD, civil, commercial and/or test/evaluation event if the commander or director determines that the event is or would be detrimental to public health and safety, public or private property, or any national security interest of the United States. Reference DoDI 3200.18. The Wing Safety Office shall document all determinations made and forward to the MAJCOM Safety Office. (T-3)

4.3. Pre-Launch Safety.

4.3.1. This section covers safety responsibilities for space-related hardware, space program operations, and space program facilities during activities (to include testing) at the launch base prior to launch countdown operations.

4.3.2. Pre-launch Operations. Due to the inherent hazards of rockets and launch operations, the pre-launch campaign shall commence in a deliberate fashion, with formal milestones and reviews to ensure proper employment of mission readiness and adequate launch safety processes for the protection of the public and Air Force resources. A Launch Readiness Review (LRR) shall occur at the end of the pre-launch phase and before initiating final countdown so that the Space Wing Commander has assurance of launch safety and the readiness of all personnel and systems involved. (T-3)

4.3.3. IAW AFMAN 91-222, Space Wing Commanders must identify an ISB President prior to each launch from their range. AFI 91-204 outlines the duties of the ISB President. (T-3)

4.4. Launch Safety.

4.4.1. The following outlines acceptable risk levels for hazards associated with launches. Launch operations risk management shall apply risk analysis consistent with DoD, RCC, Air Force, and industry standards and practices. (T-3)

4.4.2. Personnel Risk. The risk criteria listed below applies to all launches. For FAA-licensed launches from Air Force ranges, the Air Force shall enforce FAA public risk criteria.

4.4.2.1. Public. The risk to the general public shall not exceed an individual Probability of Casualty (P_c) of 1×10^{-6} (one in one million), and the collective risk to the general public shall not exceed a casualty expectation (E_c) of 100×10^{-6} (one hundred in one million). These risk levels shall apply for all hazards from lift-off to orbital insertion, including planned debris impacts, and from lift-off to final impact for a suborbital mission. Reference RCC 321, *Common Risk Criteria Standards for National Test Ranges.*

4.4.2.1.1. When the risk from toxic hazards exists, the range shall ensure the allowable level of risk does not exceed existing safety standards for toxic exposure limits for the general public when appropriate mitigations are in place. This predetermined E_c shall account for each range's local population and population distribution, applicable national exposure guidelines, and agreements with local government authorities. The MAJCOM Safety Office is responsible for ensuring all Space Systems with radiological material are in compliance with AFI 91-110,

Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems. All systems containing an amount of radioactive material exceeding the thresholds in AFI 91-110 are subject to the Interagency Nuclear Safety Review Panel (INSRP) process.

4.4.2.2. Launch Essential Personnel. For launch essential personnel, the individual P_c shall not exceed 10×10^{-6} (ten in one million) and the collective E_c shall not exceed 300×10^{-6} (three hundred in one million) for all hazards associated with a mission. Reference RCC 321.

4.4.3. Launch Collision Avoidance (LCOLA). All launches from Air Force ranges and all Air Force launches from non-Air Force ranges shall accomplish LCOLA procedures accounting for all launched objects (e.g., booster segments, payloads, jettisoned components, and debris) with an altitude capability equal to or greater than 150 km.

4.4.3.1. Responsibilities. Launch operators/range users shall provide the launch wings and the Joint Space Operations Center (JSpOC) with planned flight profile data for all space launch vehicle and jettisoned components (to include upper stages pre-programmed for a controlled reentry, up until atmospheric reentry). Space Wing Commanders shall establish and enforce launch window hold periods, based on the LCOLA conjunction assessments computed by JSpOC against catalogued objects, and on safe separation of launched objects as defined by USSTRATCOM, IAW SD 505-1 V2, *Space Surveillance Operations – Event Processing*. For Air Force launches from non-Air Force ranges, the senior Air Force representative involved with the launch assumes responsibility of LCOLA risk management.

4.4.3.2. Timeframe. LCOLA shall cover the period of time from when launched objects achieve an altitude equal to or greater than 150 km, until location uncertainty makes performing a pre-launch safety COLA infeasible, or until the suborbital or reentry components descend to less than 150 km.

4.4.3.2.1. There is currently a gap between the end of the launch COLA and the time when JSpOC can establish a reliable track of orbital components, plus the time when an active asset can respond to a JSpOC conjunction assessment. This is known as the "COLA gap" and is a recognized deficiency in LCOLA assessments. Programs shall use industry best practices to mitigate the COLA gap risk to manned objects.

4.4.3.3. Launch window hold periods. Determine the launch window hold periods based on one or a combination of the following methodologies and criteria:

4.4.3.3.1. Probability of Collision. The probability of collision between the launch components and manned objects shall not exceed $1 \quad 10^{-6}$ (one in one million). The probability of collision between the launch components and unmanned objects (to include active satellites and orbital debris) shall not exceed 10×10^{-6} (ten in one million). Reference RCC 321.

4.4.3.3.2. Safe Separation Distance. The safe separation distance for manned objects shall consist of either ellipsoidal miss distance volumes with semi-axes of 200 km in-track, 50 km cross-track, and 50 km radial; or spherical volumes with a radius of 200 km. The safe separation distance for unmanned objects shall consist of three-sigma ellipsoidal miss distance volumes calculated from the covariance data. Where the

covariance data are not available, utilize a spherical miss distance volume with a radius of 25 km for active satellites and 2.5 km for debris.

4.4.4. Control of Errant Vehicle Flight. The Space Wing Commander must approve the methodology for controlling erratic vehicle flight while managing risks to the public and foreign countries for all vehicles launched from or onto Air Force ranges.

4.4.4.1. Range safety organizations shall establish flight safety criteria and mission flight rules to ensure operations do not exceed acceptable public safety risk criteria or limits.

4.4.4.2. Range safety organizations, with Space Wing Commander approval, shall establish and control hazardous launch areas and implement procedures to protect the public on land, on the sea, and in the air for each launch and launch vehicle using the range.

4.4.4.3. The range shall coordinate with the FAA to ensure timely notification of any expected air traffic hazard associated with range activities. In the event of a mishap, the range shall immediately inform the FAA of the affected airspace (impact on volume/duration). Similarly, the range shall coordinate with the US Coast Guard (USCG) to ensure timely notification of potentially hazarded ship traffic and in the event of mishap, inform the USCG of the affected sea area and duration of navigable waters.

4.5. Launch Vehicle EOL Requirements.

4.5.1. Any launch vehicle component that achieves orbit shall undergo passivation and disposal procedures as outlined in Chapter 5 of this document.

4.5.2. Reentry hazards posed by expended launch vehicles or other jettisoned components that achieve orbit shall be in the analysis and risk budgets of the disposal/EOL phase. Reference DoDI 3100.12.

4.6. Reentry and Recovery Safety.

4.6.1. The risk criteria listed below apply to hazards associated with reentry vehicles/components and reusable launch vehicles/components, to include their jettisoned components. They also apply to reentry of expendable launch vehicles/components, preprogrammed controlled reentry, and other forms of reentry that involve a reentry or landing site. Section 5 addresses disposal of satellites and expended launch vehicle components that remain in orbit. Reentry safety begins with the final commitment to re-enter the atmosphere (i.e., the final command that initiates or enables the entry and landing sequence) and ends when all components associated with the reentry come to rest on the Earth. Reentry operations risk management will apply risk analysis consistent with DoD, RCC, Air Force, and industry standards and practices.

4.6.2. Safety Responsibilities. Risk management responsibility directly corresponds with mission command and control authority, with the exception of the management of risks associated with destructive (non-recoverable) reentry, which the program office manages.

4.6.2.1. When reusable launch vehicles reenter/land at a different location than the launch site, the commander of the launch site is responsible for coordinating reentry/landing safety requirements with the reentry/recovery site. The commander or equivalent is responsible for requesting applicable waivers to public reentry safety risk

requirements. For FAA-licensed reentries landing at Air Force ranges, range user agencies shall comply with both FAA and Air Force reentry requirements. (T-3)

4.6.2.2. The operator or landing/recovery site commander or equivalent is responsible for all reentry risks to the general public, landing recovery area personnel, and other mission support personnel from the de-orbit initiation event through final landing and safing of the returning space vehicle. (T-3)

4.6.2.3. The Space Wing Commander or equivalent who has the last opportunity to control the reentry phase of flight shall implement the Conjunction Assessment (CA)/Collision Avoidance (COLA) process for the reentry phase of flight. This commander shall implement reentry holds to prevent collisions with any cataloged orbiting objects. This commander shall implement the reentry safety COLA to the point where the reentry vehicle descends to less than 150 km or where location uncertainty makes performing a safety COLA infeasible, whichever occurs first. (T-3)

4.6.2.3.1. For missions where the last opportunity to avert potential collisions during the reentry phase of flight is prior to the launch (e.g., preprogrammed controlled reentry), the Space Wing Commander responsible for launch shall implement reentry safety COLA. (T-3)

4.6.2.3.2. For missions externally commanding reentry at some time after launch, the Space Wing Commander or equivalent responsible for determining the date and time of reentry shall implement and enforce the safety COLA. (T-3)

4.6.2.4. The appropriate landing/recovery site shall receive, prior to launch, launching agency-authored anomaly/contingency response plans, as well as, debris and object recovery plans (e.g., land, shallow water, and deep water impacts). For uncontrolled reentries of launch vehicle objects or recovery of objects jettisoned during ascent that end up on United States or foreign land, the Launch Vehicle SPO Director shall determine whether to execute recovery plans for identified space objects. (T-3)

4.6.2.5. The reentry/recovery site commander or equivalent has the authority to approve or deny the initiation of de-orbit. This includes the planned nominal and contingency sites.

4.6.3. Personnel Risk. The public safety risk criteria listed below applies only to the mission flight phases associated with the reentry and/or recovery of a space vehicle, reusable launch vehicle, and/or the flight of any other test or operation vehicle. MAJCOM or local guidance shall determine if the risk criteria can be assigned to the individual flight phases or if it will be appropriate for the entire flight of the mission.

4.6.3.1. Public. The risk to the general public shall not exceed an individual Probability of Casualty (Pc) of 1×10^{-6} (one in one million), and the collective risk to the general public shall not exceed a casualty expectation (E_c) of 100×10^{-6} (one hundred in one million). Each major component of a mission shall have a separate risk budget (e.g., upper stage allocated $100 \ 10^{-6}$ and the spacecraft allocated $100 \ 10^{-6}$). Reference RCC 321.

4.6.3.1.1. When the risk from toxic hazards exists, the range must ensure the allowable level of risk does not exceed existing safety standards for toxic exposure

limits for the general public, when appropriate mitigations are in place. This predetermined E_c shall account for each range's local population and population distribution, applicable national exposure guidelines, and agreements with local government authorities.

4.6.3.2. Recovery Essential Personnel. For recovery essential personnel, the individual P_c shall not exceed 10×10^{-6} (ten in one million) and the collective E_c shall not exceed 300 10^{-6} (three hundred in one million) for all hazards associated with a mission. Reference RCC 321.

4.6.3.3. Additional Risk Analyses. The landing/recovery site shall ensure that any additional risk analyses required to adequately address public safety for all planned reentry events are performed. The appropriate landing/recovery site shall review and approve all risk analyses associated with each reentry event onto the range.

4.6.4. Controlled Reentry Collision Avoidance. The risk criteria listed below applies only to the hazards associated with the reentry of a launch or reentry vehicle, reusable launch vehicle, and/or the flight of any other test or operation vehicle.

4.6.4.1. Timeframe. The safe separation/COLA process based on JSpOC CAs shall account for reentry vehicle flight until the vehicle is below 150 km.

4.6.4.2. Methodologies. Determine safe controlled reentry times and trajectories based on one or a combination of the following methodologies.

4.6.4.2.1. Probability of Collision. The probability of collision between the reentry components and manned objects shall not exceed $1 \quad 10^{-6}$ (one in one million). The probability of collision between the reentry components and unmanned objects (to include active satellites and orbital debris) shall not exceed 10×10^{-6} (ten in one million).

4.6.4.2.2. Safe Separation Distance. The safe separation distance for manned objects shall consist of either ellipsoidal miss distance volumes with semi-axes of 200 km in-track, 50 km cross-track, and 50 km radial, or spherical volumes with a radius of 200 km. The safe separation distance for unmanned objects shall consist of three-sigma ellipsoidal miss distance volumes calculated from the covariance data. Where the covariance data are not available, utilize a spherical miss distance volume with a radius of 25 km.

4.6.5. Control of Errant Vehicle Flight. The Space Wing commander or equivalent responsible for reentry shall determine if the reentry vehicle requires positive control to meet the risk criteria outlined above. In the event of a positive control requirement, Range Safety shall approve the method of controlling erratic vehicle flight based on the requirements of RCC 319, *Flight Termination Systems Commonality Standard*, or equivalent. (T-3)

4.6.5.1. Range safety organizations shall establish flight safety criteria and mission flight rules to ensure operations do not exceed acceptable public safety requirements IAW MAJCOM directives. The Space Wing Commander shall approve Flight Safety System criteria and mission flight rules. The reentry mission rules shall describe circumstances that necessitate the activation of the Flight Safety System. Range Safety shall develop the mission rules with inputs from the Mission Flight Control Officer and launching agency.

4.6.5.2. Range/Wing Safety, with Space Wing Commander approval, shall establish and control hazardous areas and implement procedures to protect the public on land, on the sea, and in the air for each returning vehicle to their range IAW MAJCOM directives.

4.6.5.3. Reentering vehicles shall not violate established reentry flight safety rules.

4.7. Risk Acceptance and Waiver Authority.

4.7.1. Consistent with DoDI 5000.02, AFI 91-202, MAJCOM guidance and other agreements, the risk acceptance authorities are outlined below. Air Force exception to National Space Policy shall staff through Headquarters Air Force, Space Operations (Air Force/A3S) for Secretary of Defense approval.

4.7.2. Launch. The Space Wing Commander is the approval authority for all launch risk analyses that demonstrate compliance with the risk criteria defined in this section. Risk acceptance and waiver authority at AFSPC Ranges shall be IAW AFSPCMAN 91-7xx series publications. (T-3)

4.7.3. Reentry.

4.7.4.1. For destructive (non-recoverable) reentry, risk acceptance must be IAW DoDI 5000.02, incorporating the criteria defined in this section. Risk level will be High for hazards that exceed these criteria.

4.7.4.2. For reusable launch vehicle reentry, the recovery/landing site commander or equivalent, in conjunction with the operator, is the approval authority for all reentry risk analyses that demonstrate compliance with the risk criteria defined in this section. For risks that exceed the criteria defined in this section, the appropriate NAF Commander/SPO Director or equivalent is the approval authority.

4.7.5. For commercial/civil launches from Air Force ranges, use established interagency agreements for risk acceptance and waiver approval. For FAA-licensed launches, Air Force ranges shall enforce range user compliance with the *Title 14 of the Code of Federal Regulations, Chapter III - Commercial Space Transportation, Federal Aviation Administration, and Department of Transportation.*

4.7.6. The wing CoS/SSM shall review all waiver requests. MAJCOM's subordinate units (e.g., wings, centers, NAFs) shall provide the MAJCOM/SE copies of all dispositioned waivers. (T-3)

Chapter 5

ORBITAL SAFETY

5.1. Orbital Safety.

5.1.1. This chapter addresses Air Force owned and/or operated spacecraft and any systems that reach an altitude high enough to pose risk of collision, debris generation, or otherwise interfere with other active orbital space systems.

5.2. Orbital Safety Program.

5.2.1. All organizations with SCA or that test or operate any space system (including satellites, payloads, and experimental systems) designed to complete one or more revolutions in Earth orbit, shall establish an Orbital Safety Program. The Orbital Safety Program shall span the on-orbit testing and operation of these space systems, to include on-orbit testing and operations, reentry, recovery, and disposal. (T-2)

5.2.2. During development and on-ground testing, program offices shall incorporate the management of orbital hazards into their System Safety effort IAW DoDI 5000.02. Program offices that have SCA for systems in orbit must also have an Orbital Safety Program that meets the criteria in this section.

5.2.3. The Orbital Safety Program shall include activities associated with the disposal reentry of spacecraft. The Orbital Safety Program shall also include activities associated with the reentry and recovery (if required) of test objects, jettisoned spacecraft components, and subsidiary payloads that reenter the atmosphere in a controlled or uncontrolled manner.

5.2.3.1. Units shall provide Orbital Safety Officers (OSOs) for each Space Safety Program to manage the SCA's Orbital Safety Program, to include: (T-3)

5.2.3.1.1. Participating in all Operations Review Panel (ORP) and Operational Review Board or equivalent processes to surface trends and provide input on Space Safety related issues. (T-3)

5.2.3.2. Ensuring routine test, operations, and experimental procedures take no unnecessary risk, consistent with cost effectiveness and mission requirements. (T-3)

5.2.3.2.1. Participating in both routine operations and spacecraft anomaly recovery actions in order to gain experience and help prevent future anomalies. (T-3)

5.2.3.2.2. Tailoring local Space Safety training for operations and operational test personnel for greater applicability to the assigned mission and conditions. (T-3)

5.2.3.2.3. Assisting operations/operational test personnel in complying with Space Safety guidelines. (T-3)

5.2.3.3. Monitoring crew rest, training, system modifications, and any other aspect of operations, in order to advise the unit commander on risks to the mission. (T-3)

5.3. Orbital Mishaps and Anomalies

5.3.1. Orbital Mishaps. All mishaps that occur after successful separation from all launch vehicle components, including upper stages and transfer/kick motors, are orbital mishaps. Refer to AFMAN 91-222 for reporting and investigation requirements.

5.3.2. Anomalies. Anomalies are unexpected events that may or may not result in damage, injury, or mission impact, but do not reach the level of a reportable mishap. Investigate all spacecraft anomalies IAW AFMAN 91-222.

5.3.2.1. Organizations shall notify OSOs within 8 hours of all mission impacting or emergency anomalies/incidents and within 72 hours of all other anomalies. OSOs are full members on all Anomaly Resolution Teams, Engineering Review Boards, Operational Review Boards, and/or similar constructs and shall receive invitation to participate in all supporting events. (T-3)

5.3.2.2. Safing. Organizations testing or operating orbital spacecraft, payloads, or experiments shall have a formal and approved (wing or equivalent level) safing process that limits/prevents further mission degradation or failure. (T-3)

5.3.2.3. Reporting. To ensure proactive mishap prevention, the relevant findings and recommendations from anomaly investigations shall process through safety channels IAW AFI 91-204 and AFMAN 91-222, in addition to normal reporting channels. (T-2)

5.4. Space Debris.

5.4.1. IAW National Space Policy, the United States shall minimize debris and preserve the space environment for the responsible, peaceful use of all space-faring nations. All space systems and launch vehicles (or components) that expect to achieve orbit shall manage (mitigate and control) potential space debris generation.

5.4.2. A spacecraft's life cycle shall incorporate debris mitigation practices throughout system development, operations, disposal, reentry, and recovery. The PM shall assess the mission for compliance with DoDI 3100.12, DoDI 5000.02, and this instruction for generation of space debris during all mission phases. (T-0)

5.4.3. Space Debris Assessment Report (SDAR). For all Air Force launched objects into space, the launch vehicle PM and the spacecraft PM shall prepare and deliver applicable space debris assessments, per the format and content defined in Attachments 2 and 3. The Launch Vehicle SDAR (Attachment 2) shall address space debris associated with the launch vehicle. Spacecraft PMs shall combine the Spacecraft SDAR with the Spacecraft End-of-Life Plan (EOLP) and deliver this per the format and content defined in Attachment 3. (T-2)

5.4.3.1. The SDARs shall include an assessment of debris generation risk during launch, on-orbit operations, and EOL disposal, and shall assess compliance with the US Government Orbital Debris Mitigation Standard Practices (ODMSP). All non-compliances with the ODMSP require an approved exception to National Space Policy before launch, as soon as possible following identification. Air Force exception to National Space Policy shall staff through Headquarters Air Force, Space Operations (Air Force/A3S) for Secretary of Defense approval.

5.4.3.2. The space debris assessment shall specifically note requirements not met because of an overriding conflict with mission requirements or a prohibitive cost impact, along with the appropriate rationale and justification.

5.4.4. Spacecraft End-of-Life Plan (EOLP). All test, experimental, or operational orbital space systems shall develop EOLPs.

5.4.4.1. Spacecraft PMs shall prepare, update, and deliver a pre-launch combined SDAR/EOLP to the operator(s) using a format and content outlined in Attachment 3 for the configuration of the space vehicle anticipated at EOL. Launch vehicle PMs shall ensure the launch vehicle SDAR contains any orbital launch vehicle component EOLP information. (T-2)

5.4.5. Assessment of Debris Released During Normal Operations. PMs shall design space systems to eliminate or minimize the creation of any operational or mission-related debris. If the release of debris is unavoidable, programs shall obtain appropriate exceptions to policy and minimize the number, size, and orbital lifetime of any debris released. This requirement applies to all space systems in Earth orbit. Note: Operational or mission-related debris includes debris released during normal space operations (e.g., sensor covers, tie-down straps, explosive bolt fragments). It does not include slag ejected during the burning of a solid rocket motor or liquids dispersed from a spacecraft.

5.4.5.1. Debris passing through Low-Earth Orbit (LEO). For missions leaving debris in orbits passing through LEO, released debris with diameters of 5 mm or larger shall have maximum orbital lifetimes of 25 years from date of release. The total object-time product shall not exceed 100 object-years per mission. The object-time product is the sum over all debris of the total time spent below 2000 km altitude during the orbital lifetime of each object. Reference NASA-STD-8719.14A.

5.4.5.2. Debris passing near Geosynchronous Orbit (GEO). For missions leaving debris in orbits with the potential of traversing GEO (GEO altitude +/- 200 km and +/- 15 degrees latitude), released debris with diameters of 5 cm or greater shall be left in orbits which will ensure that within 25 years after release the apogee will no longer exceed GEO - 200 km. Reference NASA-STD-8719.14.

5.4.6. Assessment of Debris Generated by Accidental Explosions. Programs shall assess and limit the probability of accidental explosion during and after completion of mission operations through satellite decommissioning and disposal.

5.4.6.1. The PM for each spacecraft or launch vehicle shall:

5.4.6.1.1. Demonstrate via failure mode and effects analyses (or equivalent) that the integrated probability of explosion for all failure modes (excluding collisions) of each separate spacecraft and launch vehicle orbital stage is less than 1×10^{-3} (one in one thousand). Reference NASA-STD 8719.14. (T-3)

5.4.6.1.2. Ensure the design of all spacecraft and launch vehicle components include the ability to deplete onboard sources of stored energy and disconnect energy generation sources when no longer required for mission operations or post-mission disposal or control. (T-3)

5.4.6.2. The operating unit shall deplete and/or safe all onboard sources of stored energy of the space system (e.g., residual propellants, batteries, high-pressure vessels, self-destructive devices, flywheels, and momentum wheels) when no longer required for mission operations. Depletion shall occur as soon as this operation does not pose an unacceptable risk to the payload. (T-3)

5.4.7. Assessment of Debris Generated by Intentional Breakups. Programs shall assess and limit the effect of intentional breakups of spacecraft and launch vehicle orbital stages on other users of space. Consistent with cost effectiveness and mission objectives, organizations conducting intentional breakups and/or collisions shall ensure that:

5.4.7.1. Planned explosions or intentional collisions shall occur at altitudes such that, for orbital debris fragments larger than 10 cm, the object-time product does not exceed 100 object-years. No debris larger than 1 mm shall remain in Earth orbit longer than one year. Reference NASA-STD-8719.14A.

5.4.7.2. Immediately before a planned explosion or intentional collision, the probability of related debris larger than 1 mm colliding with any active spacecraft within 24 hours of the breakup shall not exceed $1 \quad 10^{-6}$ (one in one million). Reference NASA-STD 8719.14A.

5.4.8. Assessment of Debris Generated by On-orbit Collisions. In developing the design and mission profile of a space system, a program shall estimate and limit the probability of accidental collision with trackable space objects during the system's orbital lifetime.

5.4.8.1. Collisions with Large Objects. Programs shall demonstrate that, during the orbital lifetime of each spacecraft or launch vehicle component in or passing through LEO, the probability of accidental collision with space objects larger than 10 cm in diameter is less than $1 \quad 10^{-3}$ (one in one thousand). Reference NASA-STD 8719.14.

5.4.8.2. Collisions with Small Objects. Programs shall demonstrate that, during the mission of the space system, the probability of accidental collision with objects (including space debris and meteoroids) sufficient to prevent post-mission disposal is less than $1 \quad 10^{-2}$ (one in one hundred). Reference NASA-STD-8719.14.

5.5. Conjunction Assessment and Safety Collision Avoidance.

5.5.1. All active on-orbit spacecraft require an approved CA/COLA process. (T-2)

5.5.2. Through the JSpOC, JFCC Space is the lead agency for orbital conjunction assessments. All Air Force launch and orbital space systems shall use JSpOC generated CA runs for safety COLA risk decisions.

5.5.3. Consistent with mission capabilities and resource availability, Space Wings shall obtain routine conjunction assessments for their active spacecraft against all catalogued objects within JSpOC established threat thresholds.

5.5.4. The approved COLA process shall identify collision risk levels and collision risk acceptance for each Space Safety Program.

5.5.5. Close Proximity Operations. Orbital operations involving the close proximity of two or more space objects require special consideration. Formation operations typically involve

spacecraft specifically designed to operate in close proximity to one another. These operations may involve refueling or re-boosting of the 'recipient' space object.

5.5.5.1. Organizations shall develop procedures for close proximity operations, to include avoidance of unintended spacecraft-to-spacecraft contact, unnecessary debris generation, or contamination of sensitive equipment (e.g., from spacecraft thruster firings, other off-gassing).

5.6. Safe Separation to Manned and Active Spacecraft.

5.6.1. The organization with Satellite Control Authority is responsible for protecting manned spacecraft and active spacecraft following separation of the last launch vehicle component through satellite decommissioning, EOL disposal, or reentry. All orbital operations shall comply with the following risk criteria unless documented waivers exist: (T-1)

5.6.2. The probability of collision with manned spacecraft shall not exceed 1 10^{-6} (one in one million) per spacecraft.

5.6.3. The probability of collision with active satellites shall not exceed 10 x 10^{-6} (ten in one million) per spacecraft.

5.7. End-of-Life Actions.

5.7.1. All spacecraft and orbital launch vehicle components shall undergo passivation and disposal at EOL via the methods outlined in this section. (T-2)

5.7.2. Reliability of post-mission EOL operations. Programs shall ensure that all post-mission EOL operations incorporate designs for a probability of success as follows:

5.7.2.1. For EOL operations not associated with controlled reentry, analyses should demonstrate that the probability of successful execution is no less than 0.90 at EOL. This calculation builds from an initial pre-launch estimate of the ability to execute an EOL maneuver, and shall undergo periodic re-assessment during the orbital operations phase. Updates to EOL planning shall occur at major operational milestones.

5.7.2.2. For controlled reentry, the probability of success at the time of the reentry burn shall be sufficiently high so as not to cause a violation pertaining to limiting the risk of human casualty.

5.7.3. Disposal. All Air Force space systems, including research and development systems, shall comply with the disposal requirements outlined in this document and the ODMSP. Organizations with Satellite Control Authority shall utilize one of the disposal options below.

5.7.3.1. Atmospheric Reentry. The preferred disposal option is atmospheric reentry when feasible.

5.7.3.1.1. Uncontrolled Atmospheric Reentry. Leave the spacecraft or launch vehicle component in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the end of mission.

5.7.3.1.1.1. The collective risk to the general public due to uncontrolled atmospheric reentry shall not exceed a casualty expectation (E_c) of 100 x 10^{-6} (one hundred in one million).

5.7.3.1.1.2. Any maneuvers required to place the spacecraft or launch vehicle in a

compliant atmospheric reentry orbit shall comply with the requirements in Section 5.6.

5.7.3.1.2. Controlled Atmospheric Reentry. For controlled reentry of any orbiting object, the selected trajectory shall comply with the requirements in Section 4.6.

5.7.3.2. Disposal Orbits. At EOL, relocate the structure to a storage regime consistent with the ODMSP.

5.7.3.2.1. When selecting disposal orbits, operators shall account for spacecraft area/mass ratio and the effect of future orbital drift due to gravitational perturbations and other space environmental effects. Due to fuel gauging uncertainties near the end of mission, use a maneuver strategy that has the least risk of leaving the structure near an operational orbit regime.

5.7.3.3. Direct retrieval. Direct retrieval strategies shall comply with all disposal requirements in this AFI and in the ODMSP.

5.7.4. Passivation. All spacecraft and launch vehicle components, to include research and development systems, shall undergo passivation during final disposal.

5.7.4.1. During space system design and development, the PM shall identify sources or potential sources of stored energy and shall develop and implement a plan for minimizing these sources at EOL. The PM shall include a description of the passivation procedure in the SDAR and if applicable, the EOLP. This description shall not only identify the passivation actions for all sources of stored energy but also provide a notional timeline of when the actions shall take place. This plan shall identify all passivation measures, to include:

5.7.4.1.1. Burning residual propellants to depletion.

5.7.4.1.2. Venting propellant lines and tanks.

5.7.4.1.3. Venting pressurized systems.

5.7.4.1.4. Discharging batteries (or other energy storage systems) and preventing recharging.

5.7.4.1.5. Depressurizing gas and liquid filled batteries.

5.7.4.1.6. Deactivating range safety systems.

5.7.4.1.7. De-energizing control moment gyroscopes.

5.7.4.2. Residual propellants and other fluids, such as pressurant, shall undergo depletion as thoroughly as possible, either by burns or venting, to prevent accidental break-ups by over-pressurization or chemical reaction.

5.7.4.2.1. To ensure that all disposal orbit parameters are met, the final disposal operation shall account for any induced ΔV due to depletion burns/venting.

5.7.4.2.2. Sealed heat pipes and passive nutation dampers need not undergo depressurization at EOL.

5.7.4.3. Batteries shall incorporate designs, both structurally and electrically, to prevent breakups. At the end of operations, battery charging lines shall undergo de-activation.

5.7.4.3.1. The complete discharge of batteries and their subsequent disconnection from charging circuits is preferable. If this is impractical, the batteries shall be left with a permanent electrical drain to prevent recharging. If permitted by design, pressurized batteries shall undergo depressurization at EOL.

5.7.4.4. Self-destruct systems shall incorporate designs to prevent unintentional destruction due to inadvertent commands, thermal heating, and/or radio frequency interference.

5.8. Recovery Procedures.

5.8.1. It is US policy to recover identifiable debris when it lands in foreign territory or the United States. Typically, the applicable acquisition organization is responsible for Air Force owned objects/assets and shall determine recovery requirements. Develop written recovery procedures that include notification to HQ Air Force, DoD, the State Department, and other appropriate organizations through the MAJCOM Headquarters when recovery is an option in foreign territory. Recovery procedures shall include provisions for safing the objects in the event hazards remain after landing or impact.

5.9. Risk Acceptance and Waiver Approval Authority.

5.9.1. Operations. The organization with SCA is the approval authority for all operational risk analyses that demonstrate compliance with the risk criteria defined in this section. For risks that exceed the criteria defined in this section, the appropriate NAF Commander/SPO Director or equivalent is the approval authority

5.9.2. End of Life/Disposal. The program manager assesses and manages EOL/Disposal risks IAW DoDI 5000.02, incorporating the criteria defined in this section. For operational risks that exceed the criteria defined in this section, the appropriate NAF Commander/SPO Director or equivalent is the approval authority.

5.9.3. The wing CoS/SSM shall review all waiver requests. MAJCOM's subordinate units (e.g., wings, centers, NAFs) shall provide the MAJCOM/SE copies of all dispositioned waivers. (T-3)

Chapter 6

GROUND-BASED SPACE SYSTEMS

6.1. Ground-Based Space Systems.

6.1.1. Ground-based space systems include unique space support equipment as well as space-related systems that do not directly support launch operations or on-orbit satellite operations. Examples include warning, surveillance, and offensive/defensive space control systems such as the Space Surveillance Network, the Rapid Attack Identification, Detection and Reporting System (RAIDRS), and the Integrated Tactical Warning and Attack Assessment (ITW/AA) system.

6.2. Space Control Systems.

6.2.1. All organizations that test or operate space control systems shall have a Space Safety Program. Note: Consistent with MAJCOM guidelines, organizations may operate systems with tailored-down Space Safety Programs. (T-2)

6.2.2. Consistent with guidance related to hazard elimination or mitigation requirements IAW AFPD 90-8, *Environment, Safety & Occupational Health Management and Risk Management*, all space control systems shall limit the unintended effects of the system on personnel, the environment, or on other ground, air, or space systems.

6.2.3. Operators of these systems shall take special care not to produce unintended effects during operations. Reference SI 534-15, *Risk Management and Radio Frequency Deconfliction for Space Control Activities* for further information.

6.2.4. Space Safety Programs shall emphasize test program validation (to include procedures discipline, readiness reviews, and test execution risk management) and configuration control in order to minimize unintended events or failures.

6.3. Space-Related Warning Systems.

6.3.1. Warning systems have unique safety risks.

6.3.2. Operational organizations' Space Safety Programs shall address the mishap risks associated with the use of warning systems (e.g., high-powered radars, erroneous missile warning messages). (T-2)

6.3.3. Program managers shall address the mishap risks associated with the use of warning systems as a part of their System Safety effort IAW DoDI 5000.02.

6.3.4. Operational organizations and program offices shall use the following guidance to manage and assess warning system risks.

6.3.4.1. Reducing the risk of and preventing mission down time is an important aspect of mishap prevention for warning systems. Operational organizations use the same timeframes used by the controlling Air Operations Center to report down times that relate to safety and report mishaps IAW AFMAN 91-222. Program offices shall reduce the risk of mission down time as part of their overall System Safety effort.

6.3.4.2. Reducing the risk of and preventing erroneous warning information is another important aspect of mishap prevention for warning systems.

6.3.4.2.1. The mishap severity category for sending erroneous warning information to the Integrated Tactical Warning and Assessment Center is critical; the mishap severity category for erroneous warnings getting to National Command Authority is catastrophic.

6.3.4.2.2. Warning System Safety Programs shall ensure the employment of risk reduction methods to prevent the sending of erroneous data up command channels by reviewing items such as hazard reports, reported mishaps/deficiencies, test safety procedures and risk assessments, and system change proposals that impact safety.

6.3.4.3. For the purpose of operational Space Safety Program management, the mishap severity category for high-power radars causing minor injury or illness is critical; the mishap severity category for high-power radars causing death or major injury is catastrophic. Program offices shall use MIL-STD-882 severity category definitions.

6.4. Other Space systems.

6.4.1. Space-related systems that directly support multiple unrelated space systems (e.g., Air Force Satellite Control Network) shall have their own Space Safety Program. This Space Safety Program shall take into account system interfaces, capabilities, and vulnerabilities in order to assess the risks of testing or operating these systems. Note: Safety for space-related systems that directly support a single program or space system shall be in the scope of the Space Safety Program of the space system supported. (T-2)

6.5. Risk Responsibility.

6.5.1. The operational and acquisition organizations shall agree upon and document the risk responsibility for space control. Risk responsibility only applies to risks that are within the control of a particular agency/authority. The risk responsibility for the various mission phases may overlap. (T-3)

6.5.2. Throughout the life cycle, to include operations and disposal, PMs for Ground-Based Space Systems shall manage and accept all system risks IAW DoDI 5000.02 and AFI 63-101/20-101. PMs must involve operational representatives in this process.

KURT F. NEUBAUER
Major General, USAF
Chief of Safety

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

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Abbreviations and Acronyms

AFB—Air Force Base

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFPD—Air Force Policy Directive

AFSEC—Air Force Safety Center

AFSPC—Air Force Space Command

AOC—Air and Space Operations Center

CA—Conjunction Assessment

CDR—Critical Design Review

CDR JFCC Space—Commander, Joint Functional Component Command for Space

COLA—Collision Avoidance

CoS—Chief of Safety

CFR—Code of Federal Regulations

ΔV—Delta V

DoD—Department of Defense

DoDD—Department of Defense Directive

DoDI—Department of Defense Instruction

DOT—Department of Transportation

DRU—Direct Reporting Unit

Ec—Casualty Expectation

EOL—End-of-Life

EOLP—End-of-Life Plan

FAA—Federal Aviation Administration

FAA/AST—FAA Office of Commercial Space Transportation

FRR—Flight Readiness Review

GEO—Geostationary Orbit

GSU—Geographically Separated Unit

HAP—High Accident Potential

IAW—In Accordance With

INSRP—Interagency Nuclear Safety Review Panel

ISB—Interim Safety Board

ITAR—International Traffic in Arms Regulations (ITAR)

JFCC—Joint Functional Component Command

JSpOC—Joint Space Operations Center

LCOLA—Launch Collision Avoidance

LEO—Low Earth Orbit

LRR—Launch Readiness Review

LSO—Launch Safety Officer

MAJCOM—Major Command

MOA—Memorandum of Agreement

MOU—Memorandum of Understanding

MSO—Mission Safety Officer

MRTFB—Major Range and Test Facility Bases

NAF—Numbered Air Force

NASA—National Aeronautics and Space Administration

ODMSP—Orbital Debris Mitigation Standard Practices

OPR—Office of Primary Responsibility

ORP—Operations Review Process

OSO—Orbital Safety Officer

Pc—Casualty Probability or Probability of Collision

PDR—Preliminary Design Review

PM—Program Manager

RCC—Range Commanders Council

RDS—Records Disposition Schedule

RM—Risk Management

SCA—Satellite Control Authority

SDAR—Space Debris Assessment Report

SIB—Safety Investigation Board

SIO—Single Investigating Officer

SMC—Space and Missile Systems Center

SME—Subject Matter Expert

SSM—System Safety Manager

SSC—Space Safety Council

SSM—System Safety Manager

SSO—Space Safety Officer

USCG—United States Coast Guard

Terms

Acceptable Risk— Risk that the appropriate acceptance authority (as defined in DoDI 5000.02) is willing to accept without additional mitigation (MIL-STD-882).

Acquisition Organization—The government organization responsible for developing, acquiring, fielding, and sustaining either hardware or a service (e.g., launch services). For most Air Force space systems and launches, the Space and Missiles Systems Center (SMC) will usually perform this function.

Active Satellite/Active Spacecraft—Orbiting systems that serve a useful purpose or could potentially serve a useful purpose (e.g., fully mission capable, partially mission capable, on-orbit spares, in test/checkout).

Air And Space Operations Center (AOC)—The senior agency of the Air Force component commander that provides command and control of Air Force air and space operations and coordinates with other components and Services.

Anomaly—Unexpected events that may or may not result in damage, injury, or mission impact, but do not reach the level of a reportable mishap.

Anomaly Resolution Process—Any process used to resolve a spacecraft anomaly. Typically conducted by the operating/testing organization (squadron or equivalent level).

Apogee—The point of a satellite's greatest distance from the center of the Earth, where the satellite's velocity is lowest. The apogee altitude is the distance of the apogee point above the surface of the Earth.

Cataloged Objects—Items entered in the JSpOC Satellite Catalog. Some items re-enter the Earth's atmosphere after cataloging.

Casualty—A serious injury or worse, including death, for a human. For the purposes of this standard, the Abbreviated Injury Scale (AIS) Level 3 defines serious injury.

Collective Risk—The total combined risk to all individuals within a category (e.g., launch-essential personnel, general public) exposed to a particular hazard during a specific period of time or event; unless otherwise noted, the mean number of casualties predicted (E_c) to result from a given hazard. Specification of collective risk is either in "per mission" or "per year" value.

Collision Avoidance—A process designed to prevent collisions between on-orbit tracked objects or to prevent collisions between on-orbit tracked objects and launched vehicles (including spent stages)/payloads by determining and implementing courses of action through careful analysis of validated conjunction assessments and satellite health and mission requirements. The process includes establishing launch wait periods in either the launch window or spacecraft maneuvering based on validated conjunction assessments and accounts for uncertainties in spatial dispersions, arrival time of orbiting objects and/or the launch vehicle/payload, and modeling accuracy.

Commercial Launch—The term "commercial," for the purposes of the National Space Policy and this instruction, refers to space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers.

Configuration Control—Process of approving or disapproving and coordinating changes to configuration items after formal establishment of their configuration identification.

Configuration Management—Process of identifying and defining the configuration items in a system, controlling the release and change of these items throughout the system life cycle, recording and reporting the status of configuration items and change request, and verifying the completeness and correctness of configuration items.

Conjunction Assessment (CA)—A process for determining the point and time of the closest approach of two tracked orbiting objects or between a tracked orbiting object and a launched vehicle (including spent stages) or payload.

Controlled Reentry—See *Uncontrolled Reentry*. A planned reentry for which the final atmospheric penetration time is chosen through spacecraft maneuvering so as to either maximize the amount of spacecraft material that burns up in the atmosphere, limiting the potential for endangering the public, or to bring down a recoverable reentry vehicle (e.g., capsule) in a manner that does not endanger the public. This typically controls the time and place of the disposal of space objects that are at the end of their mission life or for reentry capsules.

Debris—Any non-maneuverable/non-operational orbital space system or component. This includes dead satellites and their associated components, spent launch vehicle components, and objects in orbit around the Earth created by humans but no longer serve any useful purpose. Debris includes explosion and collision fragments, slag (including dust) from solid rocket motors, surface degradation products such as paint flakes, coolant released by nuclear powered satellites, and objects released due to the impact of micrometeoroids or small debris with spacecraft.

Debris Generation—Release of objects from a spacecraft into the space environment. This generally occurs in an unpredictable and uncontrolled manner. Debris generation may be the result of a collision or an occurrence within the spacecraft.

Delta V (ΔV)— The change in the velocity vector caused by thrust measured in units of meters per second. Used as a measure of required energy (i.e., fuel) to maneuver an orbital space system from one orbit to another.

Designated Approving Official—An individual with delegated approval authority.

End—Of-Life (EOL) - Final stage of spacecraft lifetime. End result will be either recovery, reentry, spacecraft disposal (passivation), or catastrophic loss (due to on-board explosion/failure or collision with another object).

Expectation Of Casualty (E_c)—The mean number of casualties predicted to occur as a result of an operation.

Federal Aviation Administration (FAA)-Licensed Launch—Any launch issued a launch license by FAA Office of Commercial Space Transportation

Failure Modes— How a system or component might fail.

Geosynchronous Orbit (GEO)—An orbit with a period equal to the sidereal day. Typically, geosynchronous orbits have an approximate altitude of 22,300 miles (36,000 km) and an inclination between ±15º of the equatorial plane.

Hazard—Any real or potential condition that can cause injury, illness, or death to personnel; damage to or loss of a system, equipment, or property; damage to the environment; or mission degradation.

Hazardous Launch Areas—Safety clearance zones during launch operations with defined mishap probabilities, including the flight caution area, flight hazard area, vessel/boat exclusion area, and impact limit lines.

Hazardous Materials—Liquids, gases, or solids that may be toxic, reactive, or flammable, or that may cause oxygen deficiency either singularly or in combination with other materials.

High Accident Potential (HAP)—An event or occurrence that could lead (in the determination of an SSO) to a mishap or other mission impacting event. The difference between a mishap and a HAP is often luck. Regardless, the mishap prevention process is generally the same.

Human Factors—A body of scientific facts about human characteristics. The term covers all biomedical and psychosocial considerations; it includes, but not limited to, principles and applications in the areas of human engineering, personnel selection, training, life support, job performance aids, and human performance evaluation.

Inclination—The angle the orbit plane makes with the equatorial plane.

Launch Essential Personnel—The minimum number of persons necessary to successfully and safely complete an operation and whose absence would jeopardize the completion of the operation. This includes persons required to perform emergency actions according to authorized directives, persons specifically authorized by the Wing Commander/System Program Office (SPO) Director to perform scheduled activities, and persons in training. The number of mission-essential personnel allowed within Safety Clearance Zones or Hazardous Launch Areas is determined by the Wing Commander/SPO Director and the Range User with Range Safety concurrence.

Launch Mishap—See *Orbital Mishap* and *Pre-Launch*. Mishaps that occur between the initial ignition of any stage of the rocket and up until the final piece of launch hardware separates from the spacecraft. This includes payloads not launched into the intended orbit.

Launch Operation—Operations occurring in the terminal countdown through sub-orbital flight or orbital insertion.

Launch Operator—A person or entity that conducts or proposes to conduct the launch of a launch vehicle for the purpose of inserting a spacecraft into orbit or delivering a payload to a specified ballistic location.

Launch Vehicle—Any means of transportation used to place an object into Earth orbit or deep space, including ballistic missiles.

Launch Vehicle Components—All the parts of a launch vehicle except payload(s), to include upper stages and any apogee kick motors that separate from the spacecraft after operation.

Launch Window—A period of time during which the flight of a launch vehicle may be initiated to meet mission requirements.

Launching Agency—The range user at Air Force ranges or equivalent organization at other locations.

Lift-Off—For the purposes of flight safety analyses, lift-off occurs during a launch countdown with any motion of the launch vehicle with respect to the launch platform (which includes a carrier aircraft), including any intentional or unintentional separation from the launch platform.

Low Earth Orbit (LEO) There is no approved consensus definition for low earth orbit. AFDD 3-14 describes LEO as an altitude of "about 100 to 1,000 statute miles." JP 3-14 describes LEO as "generally considered to have an apogee of no more than 1000 kilometers from farthest point from the point in the orbit to the center of the earth." The UN's Inter-Agency Space Debris Coordination (IADC) Committee defines LEO as the "spherical region that extends from the Earth's surface up to an altitude (Z) of 2,000 km." This AFI utilizes the IADC term; this allows

for standardization and consistency with the US Government Orbital Debris Mitigation Standard Practices, which uses this definition.

Maneuver—Spacecraft operation designed to change the velocity (speed and/or direction) of a spacecraft using either an internal/integrated propulsion system or an externally attached booster system.

Manned Object—See *Unmanned Object*. A spacecraft that is currently occupied, or is expected to be occupied in the future. This AFI considers supply vehicles to manned spacecraft as manned objects.

Meteoroids—A solid object moving in interplanetary space, of a size considerably smaller than an asteroid and considerably larger than an atom or molecule (e.g., meteoroid material associated with asteroid breakup or material released from comets).

Mishap—A mishap is an unplanned occurrence or series of occurrences that results in damage or injury and meets Class A, B, C, D, and E mishap reporting criteria IAW AFI 91-204**.** Damage or injury includes: damage to DoD property or equipment; environmental damage; occupational illness to DoD military or civilian personnel; injury to DoD military personnel on- or off-duty; injury to on-duty DoD civilian personnel; damage to public or private property, injury or illness to non-DoD personnel caused by Air Force operations. For space mishaps, it also includes permanent or partial mission loss.

Missile—A rocket-propelled or jet-propelled expendable vehicle used to deliver a warhead. It may use a ballistic trajectory or fly under active guidance and control.

Mission Assurance—An integrated engineering-level assessment of analysis, production, verification, validation, operation, maintenance, and problem resolution processes performed over the life-cycle of a program by which an operator/user determines an acceptable level of risk to employment of a system or end item to deliver an intended capability in an intended environment. The objective of the mission assurance process is to identify and mitigate design, production, test and operational deficiencies that could impact mission success.

Mission Effectiveness—See *operational effectiveness.*

Neighboring Operations Personnel—See *Launch Essential Personnel*. Individuals required to perform safety, security, or operationally critical tasks but not associated with the specific/current operation or launch under consideration.

Non-Compliance—A noticeable or marked departure from requirements, standards, or procedures.

Orbital Mishaps—All mishaps that occur after successful separation from all launch vehicle components, including upper stages, and transfer/kick motors.

Operational Control—The authority to perform those functions of command over subordinate forces involving organizing and employing commands and forces, assigning tasks, designating objectives, and giving authoritative direction necessary to accomplish the mission. Also called OPCON.

Operational Review Process (ORP)—The panel, established in the AFI 10- series of instructions, chaired by the responsible commander that approves system modifications, training, procedures, and database changes to operational equipment.

Operational Review Board—Established in the AFI 10-series of instructions, the responsible commander that reviews problems in operations of systems chairs this board.

Operational Effectiveness—The overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected for the operational employment of the system. Can also be referred to as *mission effectiveness.*

Orbital Insertion—The point in time when an object or vehicle achieves sufficient altitude and velocity to complete at least one orbit of the Earth. This occurs when the object or vehicle achieves a minimum 130 km perigee based on a computation that accounts for drag.

Orbital Space Systems—Term used to describe the hardware and activities associated with the design, development, testing and operation of any man-made object to achieve an altitude and velocity sufficient to complete one revolution of the Earth. The lower the altitude, the shorter the orbital period. LEO orbits have orbital periods that range from about 90 minutes per orbit, with the satellite traveling just above the denser parts of Earth's atmosphere.

Passivation—The process of removing stored energy that could result in an explosion or deflagration from a space system at end-of-life. This includes electrical, mechanical, chemical, or nuclear energy.

Payload—See *Satellite* or *Spacecraft*. Refers either to the object(s) carried by a launch vehicle or the mission-performing portions of a satellite/spacecraft (e.g., the main communications package on a communications satellite). This AFI will not collectively reference a satellite/spacecraft as a "payload" following separation from the launch vehicle

Perigee—The point in the orbit nearest to the center of the Earth, and where the satellite's velocity is greatest. The perigee altitude is the distance of the perigee point above the surface of the Earth.

Pre—Launch - Space related activities occurring during ground handling, processing, and transportation operations just prior to ignition (lift-off) actions.

Post—Mission - Describes the time period after a spacecraft completes its mission and culminates with final passivation and disposal activities.

Program Manager (PM)—The designated individual with responsibility for and authority to accomplish program objectives for development, production, and sustainment to meet the user's operational needs. The PM shall be accountable for credible cost, schedule, and performance reporting to the Milestone Decision Authority (MDA). (DoDD 5000.01)

Public—See *Critical Operations Personnel*, *Launch Essential Personnel* and *Neighboring Operations Personnel*. All persons not in either the Launch Essential Personnel or Neighboring Operations Personnel categories.

Public Safety—Safety involving risks to the general public of the US or foreign countries and/or their property (both on- and off-base); includes the safety of people and property not involved in supporting a launch as well as those within the boundary of a launch site.

Radioactive Material—Materials that generate, or are capable of generating, ionizing radiation including naturally occurring radioactive materials, by-product materials, source materials, special nuclear materials, fission products, materials containing induced or deposited radioactivity, and nuclear reactors.

Range User—Any individual or organization that conducts or supports any activity on resources (land, sea, or air) owned or controlled by an Air Force range. This includes such organizations as the DoD, US government agencies, civilian launch operators, foreign government agencies, and other foreign entities that use Air Force range facilities and test equipment; conduct pre-launch and launch operations; and/or require on-orbit or other related support.

Reentry—The event occurring when a spacecraft or other man-made object comes back into Earth's dense atmosphere from higher altitudes.

Reusable Launch Vehicle—A vehicle launched into a sub-orbital or orbital trajectory, which is intended to return to the point of launch or to another designated location following payload delivery, to be recertified and reused.

Risk— See *Collective risk*. The probability and severity of loss or adverse impact from exposure to various hazards.

Risk Acceptance Authority—The individual authorized to formally accept documented risk.

Risk Analysis— The analysis of systems (hardware, software, firmware, and procedures) to determine potential hazards that could result in loss of personnel, injury to personnel, loss or degradation of the system, or loss of life or injury to the public.

Safe/Safing— Placing an object in a condition that limits the possibility of new or further system or component failures.

Safety Collision Avoidance—A collision avoidance process/analysis employed by the range to avoid potential collisions between launched vehicles/payloads and tracked manned objects on orbit for the protection of life.

Safety Critical Software— Software whose failure or malfunction may result in death or serious injury to people, loss or severe damage to property, environmental harm, or could cause permanent loss of mission.

Satellite—See *Payload* or *Spacecraft*. An object that orbits another object known as a central body. Commonly, this term refers to unmanned spacecraft in orbit around the Earth.

Satellite Control Authority—The authority to plan, schedule, and perform satellite commanding.

Separation—Occurs when the last launch vehicle component (to include non-integrated apogee kick motors) physically separates from the spacecraft. Final separation occurs when both physical separation and any tethers detach from the spacecraft.

Slag— Solid material in solid rocket motor exhaust.

Spacecraft—A man-made object either that orbits a central body (planet or star) or is in an escape trajectory (eccentricity > 1) from that central body. This can include both Earth-orbiting and interplanetary spacecraft.

Space And Missile Systems Center (SMC)—A direct reporting unit to AFSPC that develops and acquires space launch vehicles, spacecraft, and range systems for the Air Force.

Space Control—Operations to ensure freedom of action in space for the United States, its allies, and when directed, deny an adversary freedom of action in space.

Space Debris—See *Meteoroids* and *Orbital Debris*. General class of debris, including both meteoroids and orbital debris.

Space Forces—The space and terrestrial systems, equipment, facilities, organizations, and personnel necessary to access, use and, if directed, control space for national security.

Space Mishap—Any unplanned event involving space systems that results in personnel injury, system damage/destruction, or mission capability loss/delay. For reporting purposes, it also includes near misses, close calls, and HAP events.

Space Object—Any object above the Earth's atmosphere (e.g., spacecraft, debris, natural phenomena).

Space Safety—A dynamic process designed to improve operational effectiveness by managing/preventing close calls (events), reducing mishaps, and supporting mission assurance throughout the life cycle of a space system.

Space Safety Officer (SSO)— Personnel assigned to a Space Mishap Prevention or Mishap Investigation role.

Space Systems—All the devices and organizations forming the space network. These consist of: launch vehicles; launch ranges; launch and range support equipment and systems; spacecraft; ground and airborne stations; and data links among spacecraft, mission, and user terminals. Space systems refer to the equipment required for space operations, comprised of nodes and links. There are three types of nodes: space, airborne, and terrestrial. Space nodes include satellites, space stations, or reusable space transportation systems. Airborne nodes are primarily aircraft weapon systems that leverage space capabilities. Terrestrial nodes include any land or sea equipment that receives, processes, or uses data derived from space capabilities. Information conduits called links tie these nodes together. There are two classification types of these links: control and mission. Space operators use control links to operate Space systems. Space systems disseminate data on mission links, which enable force multiplication.

Space Vehicles—Devices, manned and unmanned, designed for orbit about the Earth or into a trajectory toward another celestial body. This definition differentiates between vehicles that remain in space (included) and vehicles that are suborbital (excluded).

Space Wing Commander/System Program Office (SPO) Director—Commander/Director of a wing/office that acquires, operates, or supports Space Systems.

Spacecraft—See *Satellite* and *Payload*. An object designed to perform some function in space. This includes satellites and manned objects in space. This term can also refer tothe object while it is still on the ground. This does NOT include launch vehicle components separated from the spacecraft.

Suborbital—An object trajectory that does not complete a complete orbit.

System Safety—The application of engineering and management principles, criteria, and techniques throughout all phases of the system life-cycle to optimize safety within the constraints of operational effectiveness, time, and cost.

Tolerable Risk—A predetermined criterion or standard for a maximum risk ceiling which permits the evaluation of cost, national priority interests, and number of conducted tests. These

are risks the range Commander may tolerate to secure certain benefits from a range activity with the confidence of proper risk management within prescribed limits (RCC 321).

Uncontrolled Reentry—See *Controlled Reentry*. A random reentry in which the spacecraft/object reenters the atmosphere where an operator cannot sufficiently determine or influence the surface impact point prior to reentry. This is the typical reentry method for debris and spacecraft in decay orbits where the final reentry point and time is underdetermined due to uncertainty in atmospheric density conditions due to the extended time period between disposal and reentry.

Unique Space Support Equipment—Systems, equipment, and facilities required for supporting other space systems. Includes launch and orbital space support systems.

Unmanned Object—See *Manned Object*. A spacecraft that is neither currently occupied nor expected to be occupied in the future by human beings.

Upper Stage—Typically the last portion of a launch vehicle used to deliver a spacecraft into orbit. Some spacecraft may also have an apogee kick solid-rocket motor or other propulsion system, to include mono or bi-propellant chemical rocket engine thrusters, electric, or ionic propulsion thrusters.

Attachment 2

LAUNCH VEHICLE SPACE DEBRIS ASSESSMENT REPORT (SDAR)

A2.1. Delivery Requirements

Note: SDAR delivery will be IAW the requirements specified below. The normal schedule is:

A2.1.1. PDR draft SDAR: 30 days prior to the program or project PDR or equivalent program/project development milestone. The PM receives the draft document and distributes it to the Chief Engineer and Safety Office and other offices as required. The purpose of preparing the report early in the design and development process is to ensure early identification of orbital debris issues when resolutions are least costly to implement. Any orbital debris mitigation compliance issues not resolved by the PDR require resolution no later than the CDR or equivalent program/project development milestone.

A2.1.2. CDR draft SDAR: 45 days prior to the program or project CDR or equivalent program/project development milestone. The purpose of the CDR draft is to update and clarify the issues and changes to the PDR Draft. The PM will submit the CDR draft for review and concurrence to the Center-level (or equivalent) Chief Engineer, both the Center-level and NAF-level (or equivalent) Safety Offices, and any other offices as required. Appropriate operations (NAF-level or equivalent) commanders (or their designated approving officials) shall accept non-compliances with published criteria specified in this instruction that exist at CDR. The appropriate Acquisition official IAW DoDI 5000.02 shall accept the mishap risk associated with the hazard referred to in the criteria. JFCC Space will receive an information copy of the CDR draft SDAR.

A2.1.3. Final Launch Vehicle SDAR: The PM will submit the Final Launch Vehicle SDAR 30 days prior to the launch approval process (Air Force Operational Readiness Review (ORR) or Flight Readiness Review (FRR) or equivalent) for approval and signature by the appropriate acquisition authorities (Center Commander or equivalent, or designated approving official). Prior to SDAR approval signature by the appropriate acquisition authority, the Center (or equivalent) technical and/or safety subject matter expert (SME) will independently review the final launch vehicle SDAR. In addition, in the event of non-compliances requiring user concurrence on risk acceptance, the NAF (or equivalent) technical and/or safety SME will also review the final launch vehicle SDAR prior to approval. CDR JFCC Space will receive an information copy of the signed final SDAR prior to launch. Air Force exception to National Space Policy shall staff through Headquarters Air Force, Space Operations (Air Force/A3S) for Secretary of Defense approval.

A2.2. Format

Note: Each launch vehicle SDAR will follow the format shown in Table A2.1 below and, at a minimum, include the content indicated. The draft SDAR must be in electronic form only.

Table A2.1. SDAR Format.

Cover and Front Matter
Cover showing the document version and date of delivery
Inside cover signed by (at a minimum): document preparer(s), program management, Chief

Engineer, and Safety Office reviewers.

Statement of any restrictions on the data in the SDAR such as proprietary, International Traffic in Arms Regulations (ITAR), or export controls. If the document does not contain any restrictions, then include a statement to that effect. If the document does contain restricted information, then summarize and clearly mark on the page(s) where it occurs and on the cover.

The document history page shows each version of the report. This page will include reviews of the previous versions by the Chief Engineer or Safety Office.

Section 1: Program Management and Mission Overview

a. Identification of the program sponsoring the mission and the PM

b. Identification of any mission partners' participation in the program and a summary of the Air Force's responsibility under the governing agreement(s)

c. Schedule of mission design and development milestones through proposed launch date, including PDR and CDR (or equivalent) dates

d. Summary table indicating compliance or noncompliance with each debris mitigation requirement of DoDI 3100.12 and this instruction

e. Brief description of the mission

f. Identification of the anticipated launch site

g. Identification of the proposed launch date and mission duration

h. Description of the launch and deployment profile, including all parking, transfer, and operational orbits with apogee, perigee, and inclination

i. Identification of all launch vehicle orbital stages and all other launch vehicle released objects (> 5 mm in diameter), including their orbital parameters, following insertion of the spacecraft into a mission orbit or into an Earth escape orbit

j. Identification of any interaction or potential physical interference with other operational spacecraft

Section 2: Spacecraft Description

a. Brief physical description of the spacecraft, including spacecraft bus, payload, and all appendages, such as solar arrays, antennas, and instrument or attitude control booms

b. Illustration of the entire spacecraft in the mission operation configuration

c. Total spacecraft mass at launch, including all propellants and fluids

d. Dry mass of spacecraft at launch, excluding solid rocket motor propellants

e. Description of all propulsion systems (cold gas, monopropellant, bipropellant, electric, nuclear)

f. Identification of any radioactive materials on board

Section 3: Launch Vehicle Description

a. Identification of launch vehicle used

b. Identification of any upper stages used

c. Identification of any launch vehicle stage identified for permanent insertion into Earth orbit

d. Dry mass of each orbital stage after spacecraft deployment

e. Detailed illustration of each orbital stage

Section 4: Assessment of Launch Vehicle Debris Released during Normal Operations

a. List of any object(s) greater than 5 mm identified for release into Earth orbit from any stage, including, but not limited to, dual payload attachment fittings and stage separation devices

b. Rationale/necessity for release of each object

c. Time of release of each object, relative to launch time

d. Release velocity of each object with respect to orbital stage

e. Expected orbital parameters (apogee, perigee, and inclination) of each object after release

f. Calculated orbital lifetime of each debris object until reentry

g. Assessment of launch vehicle compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 5: Assessment of Launch Vehicle Potential for Explosions and Intentional Breakups

a. Identification of all potential causes of launch vehicle orbital stage breakup during all operations

b. Summary of failure modes and effects analyses (or equivalent analyses) of all credible failure modes which may lead to an orbital stage accidental explosion

c. Detailed plan for any designed orbital stage breakup, including explosions and intentional collisions

d. Detailed plan, under normal EOL conditions and deployment malfunction scenario, for passivating each orbital stage, including the depletion of residual propellants and fluids as thoroughly as possible

e. Assessment of launch vehicle compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 6: Assessment of Launch Vehicle Potential for On-orbit Collisions

a. Calculation of each orbital stage probability of collision with known space objects larger than 10 cm in diameter during the orbital lifetime of the stage

b. Assessment of launch vehicle compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 7: Assessment of Launch Vehicle Post-mission Disposal Plans and Procedures

a. Description of orbital stage disposal option selected

b. Plan for any orbital stage maneuvers required to accomplish disposal after end of orbital

stage mission

c. Calculation of area-to-mass ratio after completion of all orbital stage operations, including disposal maneuvers, if the controlled reentry option not selected

d. Procedure for executing orbital stage disposal plan, including timeline from final shutdown of each orbital stage to completion of passivation and disposal operations

e. Demonstration of reliability of orbital stage disposal operations

f. Assessment of launch vehicle compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 8: Assessment of Launch Vehicle Reentry Hazards

Note: if a reentry hazard assessment already exists for an orbital stage, refer to that report and make any necessary adjustments for orbital inclination and year of reentry

a. Detailed description of launch vehicle components by size, mass, material, and shape, if atmospheric reentry option selected

b. Summary of objects expected to survive an uncontrolled reentry, specifying software tool(s) used for the analysis (such as NASA Debris Assessment Software (DAS), NASA Object Reentry Survival Analysis Tool (ORSAT), or comparable software)

c. Calculation of expectation of human casualty for the expected year of uncontrolled reentry and the orbital stage inclination

d. If appropriate, preliminary plan for launch vehicle controlled reentry

e. Assessment of launch vehicle compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 9: Reference List

a. Complete reference list of cited material, analysis, and requirements

A2.3. Review

Note: The Center Chief Engineer in coordination with the Center Safety Office will review each SDAR delivered and provide recommendations for improvements to the PM.

Attachment 3

COMBINED SPACE VEHICLE DEBRIS ASSESSMENT REPORT/END-OF-LIFE PLAN (SDAR/EOLP)

Note: The SDAR/EOLP will be a living document that evolves with the program.

A3.1. Delivery Requirements

Note: Deliver IAW the requirements specified below. The normal schedule is:

A3.1.1. PDR draft SDAR/EOLP: 30 days prior to the program or project PDR or equivalent program/project development milestone. The PM receives the draft document and distributes it to the Chief Engineer and Safety Office, and other offices as required. The purpose of preparing the report early in the design and development process is to ensure early identification of orbital debris issues when resolutions are least costly to implement. Any orbital debris mitigation compliance issues not resolved by the PDR require resolution no later than the CDR or equivalent program/project development milestone.

A3.1.2. CDR draft SDAR/EOLP: 45 days prior to program CDR for the spacecraft or equivalent program/project development milestone. The PM will submit the preliminary draft for review and concurrence to the Center-level (or equivalent) Chief Engineer, both the Center-level and NAF-level (or equivalent) Safety Offices, and any other offices as required. The purpose of preparing the plan early in the operational development process is to ensure identification of any orbital debris or EOL issues early when resolutions are least costly to implement. The appropriate operations (NAF-level or equivalent) commanders (or their designated approving officials) shall accept non-compliances with published criteria specified in this instruction that exist at CDR. The appropriate Acquisition official IAW DoDI 5000.02 shall accept the mishap risk associated with the hazard referred to in the criteria. JFCC Space will receive an information copy of the Preliminary SDAR/EOLP.

A3.1.3. Final pre-launch SDAR/EOLP: The PM will submit the final pre-launch SDAR/EOLP 30 days prior to the launch approval process (Air Force ORR or FRR or equivalent) for approval and signature by the appropriate acquisition authorities (Center Commander or equivalent, or designated approving official). Prior to SDAR/EOLP approval signature by the appropriate acquisition authority, the Center (or equivalent) technical and/or safety subject matter expert (SME) will independently review the final pre-launch SDAR/EOLP. In addition, in the event of non-compliances requiring user concurrence on risk acceptance, the NAF (or equivalent) technical and/or safety SME will also review the final pre-launch SDAR/EOLP prior to approval. JFCC Space will receive an information copy of the signed final pre-launch SDAR/EOLP prior to the launch. Air Force exception to National Space Policy shall staff through Headquarters Air Force, Space Operations (Air Force/A3S) for Secretary of Defense approval.

A3.1.4. The operating unit shall update the SDAR/EOLP at the major program operational milestones identified in the SDAR/EOLP. Updates shall have the following title:

[date] Update to the SDAR/EOLP.

A3.1.5. Develop/deliver the final operational SDAR/EOLP IAW USSTRATCOM and Air Force operational guidance.

A3.1.6. The Center/NAF/Wing-level (or equivalent) technical and safety SMEs will independently review each SDAR/EOLP developed/delivered IAW this instruction. The draft SDAR/EOLP must be in electronic form. Final signed SDAR/EOLP will be in both electronic and paper copies. (T-3)

A3.2. Contents of SDAR/EOLP

Note: Table A3.1 below parenthetically identifies the data added during operations; the required assessments will reflect achieved operational orbit parameters and on-orbit state of the spacecraft.

Table A3.1. Contents of SDAR/EOLP.

Cover and Front Matter
Cover showing the document version and date of delivery
Inside cover signed by (at a minimum): document preparer(s), program management, Chief Engineer, and Safety Office reviewers.
Statement of any restrictions on the data in the SDAR/EOLP such as proprietary, International Traffic in Arms Regulations (ITAR), or export controls. If the document does not contain any restrictions, then include a statement to that effect. If the document does contain restricted information, then summarize and clearly mark on the page(s) where it occurs and on the cover.
The document history page shows each version of the report. This page will include reviews of the previous versions by the Chief Engineer or Safety Office.
Section 1: Program Management and Mission Overview
a. Identification of the program sponsoring the mission and the PM
b. Identification of any mission partners' participation in the program and a summary of the Air Force's responsibility under the governing agreement(s)
c. Schedule of mission design and development milestones through proposed launch date, including spacecraft PDR and CDR (or equivalent) dates
d. Schedule of mission operational milestones from launch through EOL
e. Summary table indicating compliance or noncompliance with each debris mitigation requirement of DoDI 3100.12 and this instruction
f. Brief description of the mission
g. Description of operational orbits with apogee, perigee, and inclination
h. Chronology of management reviews of the EOLP to include changes in spacecraft operability which may affect the ability to passivate and dispose per the plan in Section 6 of the EOLP
i. Identification of the anticipated launch vehicle and launch site
j. Identification of the proposed launch date and mission duration
k. Identification of all released objects (> 5 mm in diameter), including their orbital parameters following insertion of the spacecraft into a mission orbit or into an Earth escape orbit

l. Identification of any interaction or potential physical interference with other operational spacecraft

Section 2: Spacecraft Description

a. Physical description of the spacecraft, including spacecraft bus, payload, and all appendages, such as solar arrays, antennas, and instrument or attitude control booms

b. Detailed illustration of the entire spacecraft in the mission operation configuration

c. Total spacecraft mass at launch, including all propellants and fluids

d. Dry mass of spacecraft at launch, excluding solid rocket motor propellants

e. Total mass of post-passivation spacecraft, including all propellants and fluids

f. Description of all propulsion systems (cold gas, monopropellant, bipropellant, electric, nuclear)

g. Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on- board during mission, including end-of-life maneuvers

h. Description of all fluid systems, including size, type, and qualifications of fluid containers such as propellant and pressurization tanks

i. Description of all active and/or passive attitude control systems with an indication of the normal attitude of the spacecraft with respect to the velocity vector

j. Description of any range safety or other pyrotechnic devices

k. Description of the electrical generation and storage system

l. Identification of any other sources of stored energy not noted above

m. Identification of any radioactive materials on board

n. Table of the following on board the spacecraft at time of issue of SDAR/EOLP version, expected at commencement of passivation, and expected at completion of passivation. *(Data to be updated during operations.)*

- Fluids
- Pyrotechnic devices
- Electrical generation and storage system
- Identification of any other sources of stored energy not noted above
- Any radioactive materials

o. List of changes in the propulsion systems and energy systems which have occurred since launch. Include a detailed illustration of the entire spacecraft in the EOL configuration. (*data added during operations*)

p. Status of the major systems on board the spacecraft, including any changes in redundancy *(data added during operations)*

Section 3: Assessment of Spacecraft Debris Released On Orbit

a. Identification of any object (>5 mm) expected to release from the spacecraft any time after launch, including object dimensions, mass, and material

b. Rationale/necessity for release of each object

c. Time of release of each object

d. Release velocity of each object with respect to spacecraft

e. Expected orbital parameters (apogee, perigee, and inclination) of each object after release

f. Calculated orbital lifetime of each object, including time spent in LEO

g. Assessment of spacecraft compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 4: Assessment of Spacecraft Potential for Explosions and Intentional Breakups

a. Identification of all potential causes of spacecraft breakup, including during and after passivation

b. Summary of failure modes and effects analyses (or equivalent analyses) of all credible failure modes which may lead to an accidental explosion

c. Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions

d. List of components identified for passivation at EOL, including method of passivation

e. Rationale for all items identified for passivation but not designed to be passivated

f. Assessment of spacecraft compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 5: Assessment of Spacecraft Potential for On-orbit Collisions

a. Calculation of spacecraft probability of collision with known space objects larger than 10 cm in diameter during the orbital lifetime of the spacecraft

b. Identification of all systems or components required to accomplish any post-mission disposal operation, including passivation, and maneuvering

c. Calculation of spacecraft probability of collision with space objects, including orbital debris and meteoroids, of sufficient size to prevent post-mission disposal

d. Assessment of spacecraft compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 6: Assessment of Spacecraft Post-mission Disposal Plans and Procedures

a. Demonstration of reliability of post-mission disposal operations

b. Description of spacecraft disposal option selected

c. Plan for any spacecraft maneuvers required to accomplish post-mission disposal

d. Calculation of area-to-mass ratio after post-mission disposal, if controlled reentry option

not selected

e. Procedure for executing post-mission disposal plan

f. Detailed plan for passivation of the spacecraft, including the depletion of residual propellants and fluids as thoroughly as possible, the disabling of charging circuits, and the de-energizing of rotational energy sources

g. Assessment of spacecraft compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 7: Assessment of Spacecraft Reentry Hazards

a. Detailed description of spacecraft components by size, mass, material, and shape, if atmospheric reentry option selected

b. Summary of objects expected to survive an uncontrolled reentry, specifying software tool(s) used for the analysis (such as NASA Debris Assessment Software (DAS), NASA Object Reentry Survival Analysis Tool (ORSAT), or comparable software)

c. Calculation of expectation of human casualty for the expected year of uncontrolled reentry and the spacecraft orbital inclination

d. If appropriate, preliminary plan for spacecraft controlled reentry

e. Assessment of spacecraft compliance with the relevant paragraphs of DoDI 3100.12 and this instruction, and the rationale for any non-compliances

Section 8: Assessment for Tether Missions

a. Type of tether (e.g., momentum, electrodynamic)

b. Description of tether system, including (1) tether length, diameter, materials, and design (single strand, ribbon, multi-strand mesh) and (2) end-mass size and mass remaining at EOL

c. Determination of minimum size of object that will cause tether severance

d. Tether mission plan, including duration and post-mission disposal

e. Probability of tether colliding with large space objects

f. Probability of tether severance during mission or after post-mission disposal

g. Maximum orbital lifetime of a severed tether fragment

h. Assessment of compliance with the relevant paragraphs of DoDI 3100.12, and the rationale for any non-compliances

Section 9: Reference List

a. Complete reference list of cited material, analysis, and requirements

A3.3. Review

Note: The Center Chief Engineer in coordination with the Center Safety Office will review each SDAR/EOLP delivered and provide recommendations for improvements to the PM.